E-ISSN: 2278–179X

JECET; December 2012 -February 2013; Vol.2.No.1, 39-45.

Journal of Environmental Science, Computer Science and Engineering & Technology

Available online at www.jecet.org

Computer Science

Research Article

Using Back-Propagation Recognition of Facial Expression

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Received: 12 November 2012**; Revised:** 30 November 2012**; Accepted:** 7 December 2012

ABSTRACT: Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an *expert* in the category of information it has been given to analyse. Concerning image processing it is very interesting to recognize the human gesture used for general life applications. For instance, observing the gesture of a driver when he/she is driving and alerting him/her when in sleepy mood will be quite useful. Human gestures can be identified by observing the different movements of eyes, mouth, nose and hands. Here we are focusing on the human face for recognizing expression. Many techniques are available to recognize face. This paper planned facial expression recognition using back-propagation of neural network. The procedures are image capturing, face detection, filtering, facial feature extraction and recognition using neural network. The proposed method can recognize the facial expression from image captured well.

Keywords - Edge Detection, Face Detection, Gesture Recognition, Neural Network.

INTRODUCTION

An Artificial Neural Network[1-7] is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements called neurons, working in unison to solve specific problems. ANNs, like people, learn by example[8-11]. An ANN is configured for a specific application, such as pattern

recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons.

The term neural network was traditionally used to refer to a network or circuit of biological neurons. The modern usage of the term often refers to artificial neural networks, which are composed of artificial neurons or nodes. Thus the term has two distinct usages:

- Biological neural networks are made up of real biological neurons that are connected or functionally related in a nervous system. In the field of neuroscience, they are often identified as groups of neurons that perform a specific physiological function in laboratory analysis[12-14].
- Artificial neural networks are composed of interconnecting artificial neurons i.e. programming constructs that mimic the properties of biological neurons[15-19]. Artificial neural networks may either be used to gain an understanding of biological neural networks, or for solving artificial intelligence problems without necessarily creating a model of a real biological system. Good performance (e.g. as measured by good predictive ability, low generalization error), or performance mimicking animal or human error patterns, can then be used as one source of evidence towards supporting the hypothesis that the abstraction really captured something important from the point of view of information processing in the brain. Another incentive for these abstractions is to reduce the amount of computation required to simulate artificial neural networks, so as to allow one to experiment with larger networks and train them on larger data sets.

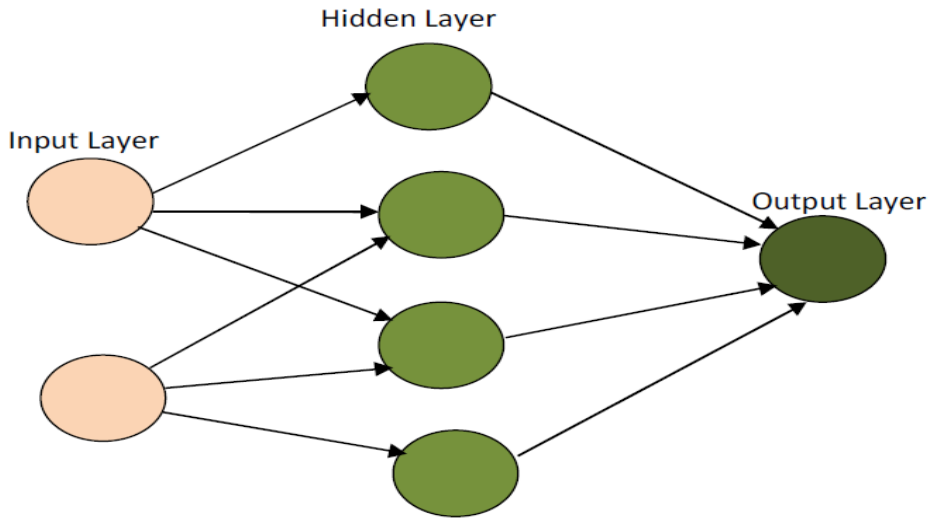

Figure 1: A Simple Neural Network

Many experiments have been reported toward facial expression recognition. In this work, the motion information is used to detect the face in real time video which is obtained from a camera. The facial detection is used to extract the feature which is useful to recognize a human expression and a human emotion later. There are many ways to extract the facial features to be input in facial expression recognition.

Initially, it is important that the machine can detect and tracking the face. This procedure is used for capturing the moving face. Next procedure is extracting the image captures by camera. The method to recognize the facial expression in this work is back-propagation of feed-forward neural network. We define input and target as training pairs. The input are the data from forehead wrinkle, mid forehead wrinkle, cheek wrinkle and mouth length, while six output of facial expressions are defined, i.e. anger, disgust, surprise, happiness, sadness and fear to be recognized. After we train it, the proposed method can recognize the facial expression from image captured well.

EXTRACTION OF FACIAL FEATURE

The face of a human has several features such as, mouth, eyes, nose, eyebrows, and forehead. Each of this features has a unique shape and a unique pattern, hence, many experiments have been reported in extracting facial feature for recognizing facial expression. Yh- yeong Chang et.al[11] used eyebrows, eyes, and mouth for facial expression labelling. We extract the features toward forehead wrinkle, mid forehead wrinkle, cheek wrinkle, and mouth length as seen in **Figure 2**.

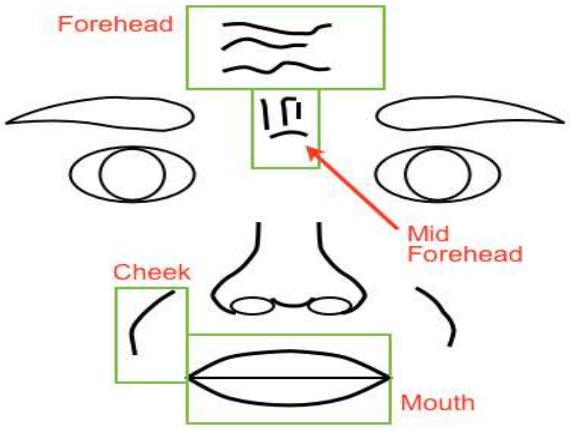

Figure 2: Parts of Facial Feature Extracted

Line Face Detection: Facial features extracted using edge detection and morphology technique to obtain the lines on the face. We used Canny edge detection. Before applying Canny edge detection method, at first, the images should be optimized using brightness and contrast tuning as shown in **Figure 3**. The aim of this optimizing is to detect the vague lines such as the face wrinkle.

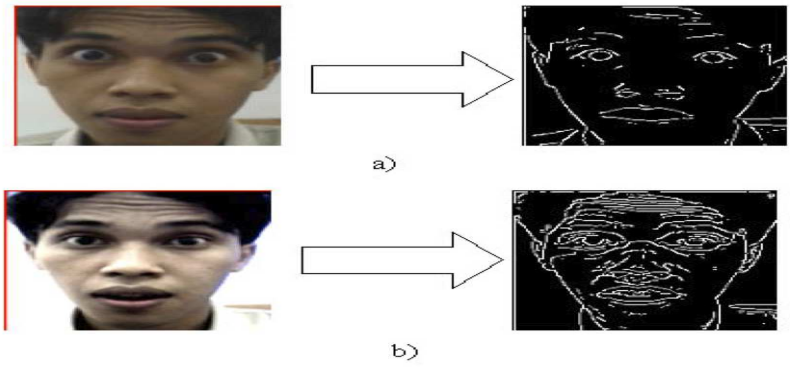

Figure 3: The image processing (a) Canny edge detection with no contrast and brightness tuning, (b) Canny edge detection with contrast and brightness tuning

Canny Edge Detection: The Canny edge detector uses a filter based on the first derivative of a Gaussian, because it is susceptible to noise present on raw unprocessed image data, so to begin with, the raw image is convolved with a Gaussian filter. The result is a slightly blurred version of the original which is not affected by a single noisy pixel to any significant degree. The next is finding the intensity gradient of the image. An edge of an image may point in a variety of directions, so the Canny algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image. The edge detection operator returns a value for the first derivative in the horizontal direction (Gy) and the vertical direction (Gx).

From this the edge gradient and direction can be determined:

$$|Gj| = |Gx| + |Gy| \qquad (1)$$

next is finding the edge direction. The formula for finding the edge direction is:

$$\theta = inv\ tan(Gy/Gx) \qquad (2)$$

The edge direction angle (θ) is rounded to one of four angles representing vertical, horizontal and the two diagonals (0^o; 45^o; 90^o and 135^o for example). Once the edge direction is obtained, the next step is related the edge direction to a direction that can be traced in an image. Finally, hysteresis is used as a means of eliminating streaking. Hysteresis uses two thresholds, a high and a low. Any pixel in the image that has a value greater than T_1 is presumed to be an edge pixel, and is marked as such immediately. Then, any pixels that are connected to this edge pixel and that have a value greater than T_2 are also selected as edge pixels.

Morphology Technique: For morphology, we use two operations, dilation and erosion for getting a potential area for edge intensity. The dilation and erosion operators for greyscales images are defined conventionally. We define the edge intensity θ_{edge} as

$$\theta_{edge} = dilation - erosion \qquad (3)$$

The data from the lines on face feature, such as mouth, are obtained using morphology technique because using edge detection can cause many of noises. While the data from the face wrinkle easy to be applied by usual edge detection, such as Canny edge or Sobel edge detection. Once the line is obtained, the next step is counting the number of the wrinkle and the result is as percentage how serious a face did an expression.

TRAINING AND BACK PROPAGATION NEURAL NETWORK

We use back-propagation algorithm to recognize of facial expression with feed-forward architecture. Back-Propagation neural networks are the most widely used network and are considered the work horse of artificial neural network. It can be used to model complex relationships between inputs and outputs or to find patterns in data. The back-propagation of feed-forward architecture is designed based on facial features extracted as illustrated in Figure 4. It consists of (1) an input layer containing four neurons representing input variable to the problem, that is extracted data from the forehead wrinkle, the mid forehead wrinkle, the cheek wrinkle, and the mouth length; (2) one hidden layers containing one or more neurons to help capture the nonlinearity in the data; and (3) an out-put layer containing six nodes representing output variable to the problem, that is facial expressions: anger, disgust, surprise, happiness, sadness and fear. The neurons between layers are fully interconnected with weight v_{ij} and w_{ij}.

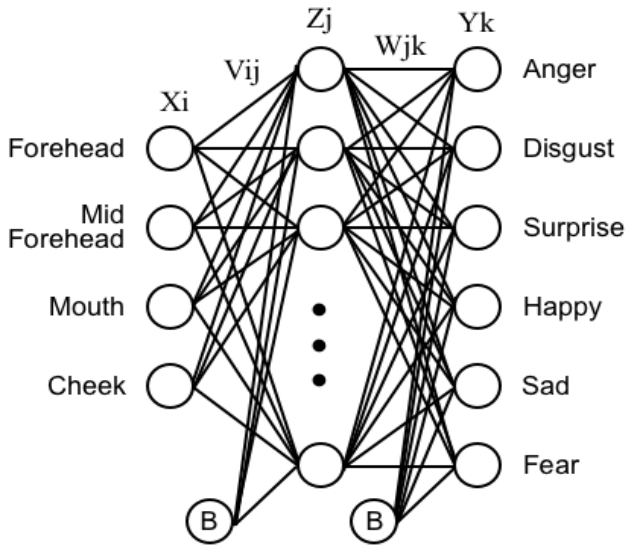

Figure 4: Architecture of feed-forward back-propagation neural network for facial expression recognition

The training of a network by back-propagation neural network involves three stages: the feed-forward of the input training pattern, the calculation and back-propagation of associated error, and the adjustment of the weights. The data are fed forward from the input layer, through hidden layer, to output layer without feedback. Then, based on the feed-forward error back-propagation learning algorithm, back-propagation will search the error surface using gradient descent for point(s). Based on the error, the portion of error correction is computed, and then the weights for all layers are adjusted simultaneously.

In many neural network applications, the data (input or target patterns) have the same range of values. We use the binary sigmoid function, which has range of (0, 1) and is defined as $f(x) = 1/ (1 + \exp (-x))$, that's why the data is also represented in binary form or has range of 0-1. The representation data of input is explained in the section before. **Table 1** shows the data of training pairs (input and target patterns) in back-propagation of neural network. We use two pairs of training input data for each of six output expressions. The first row is for neutral expression.

Table 1: The data of training pairs in back-propagation of neural network

Input				Output					
Forehead	Mid Forehead	Mouth	Cheek	Anger	Disgust	Surprise	Happy	Sadness	Fear
0	0	0	0	0	0	0	0	0	0
0	1	0	0	1	0	0	0	0	0
0	1	1	0	0	1	0	0	0	0
1	0	1	0	0	0	1	0	0	0
0	0	0	1	0	0	0	1	0	0
1	1	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	1
0	0.5	0	0	0.5	0	0	0	0	0
0	0.6	0.2	0	0	0.5	0	0	0	0
1	0.15	0	0	0	0	0.5	0	0	0
0	0	0	0.3	0	0	0	0.5	0	0
0.8	0.2	0	0	0	0	0	0	0.5	0
1	0.5	0.2	0	0	0	0	0	0	0.5

RECOGNITION

Once the training is over, the network is ready to recognize gesture presented at its input. For recognizing the gesture of a face two options are provided. If user wants to recognize the gesture of existing image, then it can be loaded from memory. As the user selects the image, the face recognition method works and returns the face part of the image. And other option is to capture the live image. Image is captured from the web cam. For testing purpose “Logitech Quick Cam Pro” is used. Once asked to recognize, it captures the image and finds the face part in it. Then the edge detection, thinning, and token generation are performed. Then it classifies the given tokens into one of three gestures it learned during training. It gives percentage of recognition to each gesture with highest percentage closely matching and lowest to the farthest matching and the closest match is considered as the result. The recognition process is implemented as per the outline given in the flow chart in F**igure 5.**

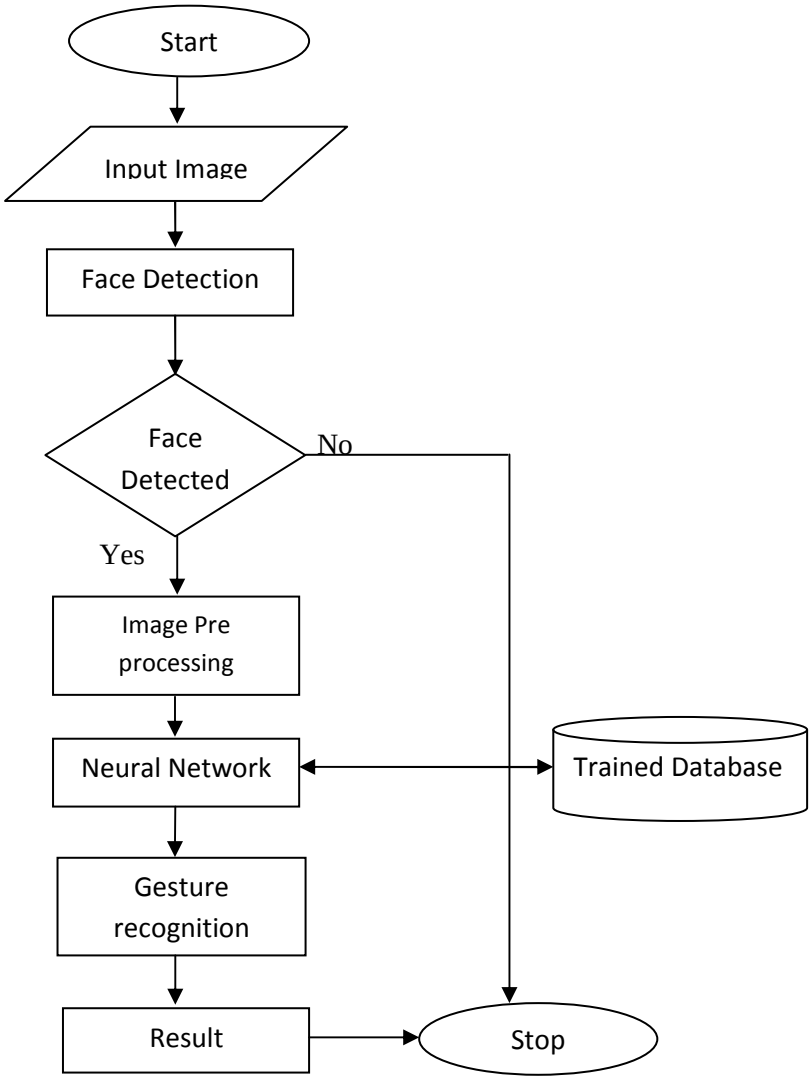

Figure 5: Flow chart of Gesture Recognition System

CONCLUSION AND FUTURE WORK

The success of the abstract message of facial expression being recognizable by the computer demonstrates that other kinds of abstract information can still be recognized by a computer, which will result in much broader applications of the computer. Human face is detected first using the technique described by Viola and Jones using Add Boost Haar classifier. Then edge detection, thinning, and token detection are performed. Then, recognition is performed. Although some positive and negative detection are found, the simplicity and robustness of the system is significant. In this system the user is recognizing the gesture by giving the input threshold value for the detection of tokens. It is a tedious task to decide the best threshold value to generate the tokens. So as a next process or the future work is to determine the best threshold value, so that without the interaction of user the system can generate the tokens.

In this paper, a simple method for facial expression recognition using back-propagation was proposed. The experimental results show that back-propagation algorithm with the facial features extracted method can recognize well the appropriate facial expressions with the higher percentage than another facial expressions. The expression of sadness and disgust are more difficult than the others to recognize.

Generally speaking, online and spontaneous expression recognition is a difficult task. We focus to tackle the recognition of subtle spontaneous facial expressions. Furthermore, we would like to apply unsupervised learning with an online clustering technique, and to estimate the intensity of facial expressions.

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